

Advanced Computing Architectures and New Programming concept Models

Najim Sheikh, Sipra Sonam, Harshada Mandhare

Department of CSE, SBIT Betul[RGPV]

Email: sheikhnajim4@gmail.com

shipra.sonam2012@gmail.com

harshada.mandhare@gmail.com

ABSTRACT

The Soft Computing is an accumulated branch of Computer Science and Engineering since it is a collection of various computational techniques, it includes the phenomenon of several other computational disciplines like Artificial Intelligence, Machine Learning, Decision Support Systems, Fuzzy Systems, Neuro Computing, Computational Intelligence etc. The guiding principle of Soft Computing is “Derive benefit from the tolerance for imprecision, uncertainty, partial truth and approximation to achieve tractability, robustness and low solution cost.” This is very important to understand that the Soft Computing is not a medley. Rather, it is an affiliation in which each member contributes a distinct methodology of solving the problem of its domain. The intention of this paper is not to provide thorough attention to all Soft Computing paradigms, but to give an overview of most popular aspects of Soft Computing.

Keywords – Computational Intelligent, Fuzzy Sets, Artificial Neural Networks, Decision Support System, Machine Learning

I. INTRODUCTION

In our day to day life we face many types of problem that we solve theoretically but which we are unable to solve analytically because it requires an enormous amount of computation and time also. Through the use of different techniques of Soft Computing we can get the answers to these real word questions which are actually very much difficult to model mathematically. The Soft Computing aims towards developing the intelligent machines that are able to solve nonlinear and mathematical problems.

The Soft Computing is new multidimensional field of Computer Science and Engineering that was proposed by Dr.Lotfi Zadeh who is a mathematician, electrical engineer, computer scientist, artificial intelligence researcher and professor of computer science at the University of California, Berkeley.

Dr.Zadeh had contributed his research towards the construction of a new generation Artificial Intelligence, known as Computational intelligence. The idea of Soft Computing was actually introduced to the world when Dr.Zadeh published his first paper on soft data analysis in 1981. According to him the Soft Computing is the fusion of the fields of the

Fuzzy Logic, Neuro Computing, Evolutionary and Genetic Computing.

Now, let's come to present from the past and discuss the future. Today, we all are the witness of the beginning of a new trend in the designing of household appliances,

consumer electronics, medical apparatus, automobiles electronic, intelligent electronic gadgets like cellular phones and many other new technology devices. This trend inquest to a sudden market increase in what might be called as Machine Intelligence (MI). Today we have several intelligent devices that can by themselves figure out their own settings in order to perform their task in an excellent way. There are many examples of such intelligent devices like Digital Camera, Automatic Washing Machines, Microwave ovens, Fire alarms, Play Stations etc.

Although, there are many factors which are responsible for the marked increased in MI. It is my personal opinion that the most important factor is Soft Computing and in particular the Artificial Intelligence. I remember a case which one of my friend told me, who is working as Resource and

planning administrator in a well known Hotel of Goa, from the past few years they are using a SAP based Decision support system in their hotel, which is used to evaluate a very huge and strong database about all the minute details of business at that place and then that system decides the tariff of rooms for different seasons, other charges and expenses too. What is important to observe here is that from past three years this decision support system had gradually increased the profit margins of that particular hotel.

This case is not the only example of what we call as Decision Support System, as we begin the 21st century; we are observing major changes in how people use computerized support in making decisions. The organizations can now easily use Intranets and Internets to deliver high performance analysis to decision makers around the world.

Deriving benefits and decision from the tolerance for imprecision and uncertainty indicates the remarkable human ability to understand several complicated things like understanding distorted speech, converting a text written in cipher into an intelligent script or language, summarizing a text, driving a vehicle in a very dense traffic road, understanding the moves of dance, and more generally, making rational decisions in an environment of uncertainty and imprecision. There is one more unmatched capability of human being to perform a wide verity of physical and mental task without any measurement and computations. Achieving the human level of intelligence by a machine has long been one of the principal objectives of the Artificial Intelligence.

Here, we can say that the Soft Computing uses the human mind as a role model and aims towards the formalization of the perceiving ability of human being towards solving the problems, taking decision of the tasks of daily life.

One major aspect of Soft Computing as stated earlier in this paper is Computational Intelligence, which is the study of intelligent agents. An agent is something that acts in an environment and it does something. Agent includes worms, dogs, thermostats, airplanes, humans, organizations, and society. An intelligent agent is a system that acts intelligently. What it does is appropriate for its circumstances and its goal. It learns from the experience, and it makes appropriate choices.

Another paradigm of Soft Computing is Neurocomputing. The Neurocomputing models are based on an artificial model of the human brain as a network of simple interconnect processing elements which corresponds to the biological neurons. The biggest advantage of such systems is that it can learn and adapt the changing environment. The knowledge

based Neurocomputing was inspired by two historical separate research areas namely Artificial Intelligence [AI] and Neural Networks [NN].

The Artificial Intelligence is the study of the computations that make it possible to perceive reason and act. Conventional AI is strongly based on symbol manipulation and formal languages in an attempt to copy and paste the human intelligence. On the other hand the neural network is a processing device, which could be either software (Algorithm) or an actual hardware device whose design was inspired by the design and functioning of the human brain. An artificial neural network tries to replace the most basic function of brain that is "Thinking".

Fredij Tekaia at the Institute Pasteur offers the definition of Bioinformatics as "The mathematical, statistical and computing methods that aim to solve biological problems using DNA and amino acid sequences and related information." As per Cynthia Gibas, Bioinformatics is the intersection of information technology and Biology. Thus we can say that Bioinformatics is a highly interdisciplinary field of biology, relying on basis principles from Computer Science, Biology, Physics, Chemistry, and mathematics.

Let us formally introduce in this paper a dynamic associate of soft Computing known as Virtual Reality. The Virtual Reality is a different way of combining high performance machines, advanced programming techniques and several other interactive devices that makes it seem as if the computer user has stepped into another world. The Virtual Reality does not actually take anybody anywhere. However, the graphics displayed by the Virtual Reality systems are so realistic and the control tools are so easy to use that user can easily think that he is in another world. This is the goal of Virtual Reality.

As mentioned earlier that Soft Computing is a multidimensional field. Combining all those multidimensional fields under one topic in a paper is a great writing challenge. To fulfill this purpose this paper is physically organized in four parts. The chapter one which is completing here was the Introduction of Soft Computing and provides a brief history about its origin and what it may cover. The second chapter starts with the introduction of Artificial Neural Networks and it attempts to introduce the evaluation and different fundamental concepts of artificial neural networks, it then describe the basic models of artificial neural networks is terms of the type of learning. In the third chapter some basic concepts of fuzzy sets are presented along with the basic notations of fuzzy sets and the elementary operations that can be done on fuzzy set.

II. ARTIFICIAL NEURAL NETWORKS

2.1 Introduction

A Neural Network can be defined as a processing device, which could either be an algorithm or an actual hardware, whose design and functioning is inspired from human or animal brain. The Neural Network has the ability to learn the things from examples and thus this special feature makes the Neural Network very flexible and powerful.

Before we actually go deep in the endless depth of Neural Network let us first discuss and understand how the human brain works. I believe that we all feel proud on this fact that human brain is a very amazing processor and it is the largest among all animals. The human brain weighs only three pounds but is estimated to have 100 billion cells. Its exact working or limitation is still a mystery and several Neuro surgeons are researching on this around the globe.

Let's start looking at the building blocks of the brain. As previously stated, the brain consists of about 100 billion cells. Most of these cells are called as Neurons.

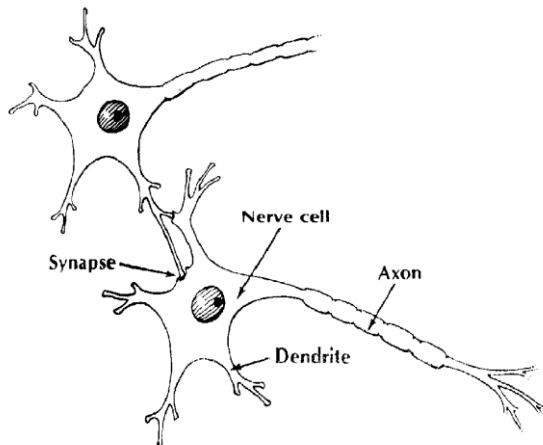


Figure 2.1: Diagram of a typical Neuron cell.

A Neuron is basically an ON/OFF switch which is just like the one which is used in our home to control the lights. It is either in resting state (off) or it is shooting an electrical impulse down a wire (on). It has a cell body, along little wire which is called as an Axon, and at very end it has a little part that shoots out a chemical. This chemical goes across a gap called as Synapse where it triggers other neurons to send a message. There are a lot of these neurons sending messages down a wire. By the way, each of these billions of axons is generating a small amount of electrical charge; this total power has been estimated to equal a 60 watt

bulb. Doctors have learned that measuring this electrical activity can tell how the brain is working.

2.2 Evolution of Neural Networks

Let us compare the human activity with neural networks. Whenever a new neural network is created it is like an infant baby. Then we start to train the network and one day it becomes expert. When it is fully trained, the neural network will never forget the things.

The evolution of neural network has gone through a rapid development of architecture and algorithms that are currently being used. The history of the development of neural networks along with the names of their designers is outlined Table 2.1.

Table 2.1. Evaluation of Neural Networks.

Year	Neural Network	Designer	Description
1958	Perceptron	Frank Rosenblatt, Block, Minsky and Papert Widrow and Hoff	Here the weights on the connection path can be adjusted.
1986	Back Propagation Network	Rumelhart, Hinton and Williams Grossberg	This network is multi layer with error being propagated backwards from the output units to the hidden units.
1988	Neo cognitron	Fukushima	This network is essential for character recognition.
1988	Radial basis function network	Broomhead and Lowe	It uses a back propagation network.

2.3 Basic Models of Artificial Neural Network

The models of Artificial Neural Network are specified by three basic entities namely:

- 1.The model's synaptic interconnections;
- 2.The training or learning ;
- 3.Their activation functions.

2.3.1 Synaptic interconnections

An artificial neural network consists of a set of highly interconnected processing elements (neurons) such that each processing output is found to be connected through weights to other processing element of to itself.

2.3.2 Learning

The main property of an artificial Neural Network is its capability of Learning. The learning or training is the process by which the Neural Network encourage itself to make the proper adjustments which results in production of desired response.

2.3.3 Activation Functions

The activation function helps to achieve the exact output. The information processing of a processing element can be viewed as consisting of two major parts input and output. An integration function is associated with the input of a processing element. This function combines the information or evidence into a net input to the processing element.

III FUZZY SETS

3.1 Introduction

In general, the entire real world is complex, and the complexity arises from the uncertainty in the form of ambiguity. We should closely look in the real world problems to find the accurate solutions.

The notation of a fuzzy set stems from the observation made Dr.Lotfi Zadeh in 1965 that "the classes of objects encountered in the real physical world do not have precisely defined criteria of membership". This observation emphasizes on the gap existing between mental representations of reality and usual mathematical representation thereof, which are based on binary logic, precise numbers, differential equation etc. The specificity of fuzzy sets is to capture the idea of partial membership. The characteristic function of a fuzzy set, often called membership function, is a function whose range is an ordered membership set containing more than two values (typically, the unit interval). Therefore, a fuzzy set is often understood as a function. The doctrine of fuzzy-ism has been properly defined by M. M.Gupta (1977) as "a body of concepts and techniques aimed at providing a systematic framework for dealing with the vagueness and imprecision inherent in human thought processes".

Human thinking and reasoning frequently involve fuzzy information, also the human can give the satisfactory answer, which are probably true or best to the underlying situation. However, our systems are unable to answer many questions. The reasons is, most of the systems are designed which are based on

classical set theory and two valued logic which are unable to cope with unreliable and incomplete information. Thus we want our system should also be able to cope with such situations and give expert opinions. Fuzzy sets have been able to provide solutions to many real world problems. Fuzzy set theory is an extension of classical set theory.

3.2 Basic Notations Of Fuzzy Set Theory

This section will provide basic definitions of fuzzy set theory. Here more emphasis is given on various representations of fuzzy set.

3.2.1 Membership Functions

A fuzzy set is a class with a continuum of membership grades. So, a fuzzy set F in a referential U is characterized by a membership function which associates with each element u in U a real number in the interval $[0, 1]$. The value of the membership function at element u represents the "grade of membership" of u in F . A fuzzy set F is thus defined as a mapping:

$$F: U \rightarrow [0,1],$$

(1)

and it is a kind of generalization of the traditional characteristic function of a subset A .

$$A: U \rightarrow \{0,1\}.$$

(2)

Note that the fuzzy sets are actually fuzzy subsets of U . There is a tendency now to identify the theory of fuzzy sets with a theory of generalized characteristics functions. This is why in the following we shall denote the membership grade of u to a fuzzy set F as $F(u)$ instead of $\mu F(u)$. In particular, $F(u) = 1$ reflects full membership of u in F , while $F(u) = 0$ expresses absolute non membership in F .

Usual sets can be viewed as special cases of fuzzy sets where only full membership and absolute non-membership are allowed. They are called crisp sets, or Boolean sets. When $0 < F(u)$

< 1 , one speaks of partial membership. For instance, the term young (for ages of humans) pictured on Figure 3.1 applies to a 30-year old individual only at degree 0.5.

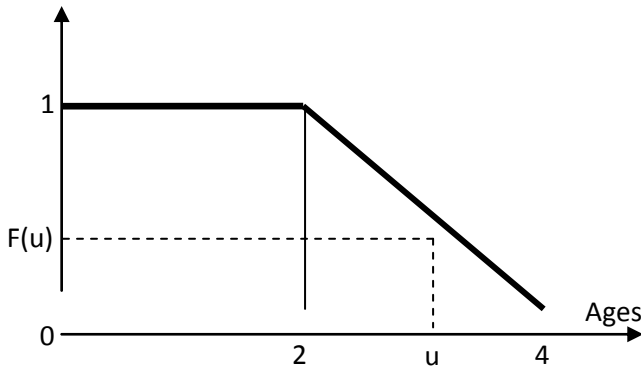


Figure 3.1: Representing young in: “a young person”.

The membership function attached to a given word (such as young) depends on the contextual intended use of the word; a young retired person is certainly older than a young student, and the idea of what is a young student also depends on the user. However, in the different contexts, young will be understood as a gradual property generally.

3.2.2 Level Cuts

Another possible and very convenient view is to consider a fuzzy set as a nested family of classical subsets, via the notion of level-cut. The α -level cut F_α of a fuzzy set F is the set $\{u \in U: F(u) > \alpha\}$, for $1 > \alpha > 0$. The idea is to fix a positive threshold α and to consider as members of the set the elements with membership grades above the threshold. Moving the threshold in the unit interval, the family of crisp sets $\{F_\alpha: 1 > \alpha > 0\}$ is generated. This is the horizontal view of a fuzzy set.

3.3 Elementary operators for Fuzzy Sets

The basic connective operations in classical set theory are those of intersection, union and complement. These operations on characteristics functions can be generalized to fuzzy sets in more than one way. In the following, only the standard operations are introduced:

3.3.1 Fuzzy AND Connective

The fuzzy intersection operator Ω applied to two fuzzy sets A and B with the membership function $\mu_A(x)$ and $\mu_B(x)$ is defined as:

$$\mu_{A\Omega B}(x) = \min \{ \mu_A(x), \mu_B(x) \}, x \in X$$

(3)

3.3.2 Fuzzy OR Connective

The fuzzy union operator U applied to two fuzzy sets A and B with the membership function $\mu_A(x)$ and $\mu_B(x)$ is defined as:

$$\mu_{A\cup B}(x) = \max \{ \mu_A(x), \mu_B(x) \}, x \in X$$

(4)

3.3.3 Fuzzy NOT operation

The fuzzy complement applied to the fuzzy set A with the membership function $\mu_A(x)$ is defined as:

$$\mu_{\bar{A}}(x) = 1 - \mu_A(x), x \in X$$

(5)

3.4 Fuzzy Systems

The idea of a fuzzy system is introduced here. The fuzzy machine is developed to solve the reasoning.

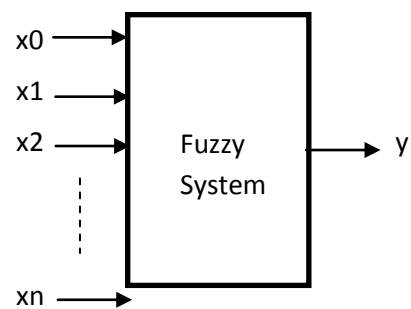


Figure 3.2: Block Diagram Of Fuzzy System.

Using multiple inputs and one output implies no restriction as a multi input multi output fuzzy system can always be decomposed into multiple systems according to figure 3.2, such systems are the basis for the realization of fuzzy controller.

Fuzzy systems are an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy, and applications at the leading edge of Artificial Intelligence. Yet, despite its long-standing

origins, it is a relatively new field, and as such leaves much room for development.

There are two main characteristics of fuzzy systems that give them better performance for specific applications

- Fuzzy systems are suitable for uncertain or approximate reasoning, especially for the system with a mathematical model that is difficult to derive.
- Fuzzy logic allows decision making with estimated values under incomplete or uncertain information.

IV MACHINE LEARNING

4.1 Introduction

It is worth noting that human learning is intrinsically multi strategy, people can learn from a great variety of input; engage any kind of prior knowledge relevant to the problem. Therefore, multi strategy learning and computer modeling of human learning have a natural interrelationship; research on human learning can provide valuable clues to multi strategy learning.

In the past, most research in machine learning was concerned with methods that employ a single learning strategy that is a mono strategy method. Such method implements one primary type of inference, such as empirical induction using one computational representation such as a decision tree, a semantic network or a classifier system.

With the growing understanding of the capabilities and limitations of mono strategy methods, there has been an increasing interest in multi strategy system that integrate multiple inference type of computational mechanism in one learning system. Such systems can learn from a wider scope of input and it can be applied to a wider range of problems.

Machine learning algorithms can figure out how to perform important tasks by generalizing from examples. This is often feasible and cost-effective where manual programming is not. As more data becomes available, more ambitious problems can be tackled. As a result, machine learning is widely used in computer science and

other fields. Machine learning is programming computers to optimize a performance criterion using example data or past experience.

The Machine Learning field evolved from the broad field of Artificial Intelligence, which aims to mimic intelligent abilities of humans by machines. In the field of Machine Learning one considers the important question of how to make machines able to “learn”. Learning in this context is understood as inductive inference, where one observes examples that represent incomplete information about some “statistical phenomenon”. In unsupervised learning one typically tries to uncover hidden regularities (e.g. clusters) or to detect anomalies in the data (for instance some unusual machine function or a network intrusion). In supervised learning, there is a label associated with each example. It is supposed to be the answer to a question about the example. If the label is discrete, then the task is called classification problem – otherwise, for real valued labels we speak of a regression problem. Based on these examples (including the labels), one is particularly interested to predict the answer for other cases before they are explicitly observed. Hence, learning is not only a question of remembering but also of generalization to unseen cases.

An important task in Machine Learning is classification, also referred to as pattern recognition, where one attempts to build algorithms capable of automatically constructing methods for distinguishing between different exemplars, based on their differentiating patterns.

A pattern (also: “example”) is described by its features. These are the characteristics of the examples for a given problem. For instance, in a face recognition task some features could be the color of the eyes or the distance between the eyes. Thus, the input to a pattern recognition task can be viewed as a two-dimensional matrix, whose axes are the examples and the features. Pattern classification tasks are often divided into several sub-tasks:

- Data collection and representation.
- Feature selection and/or feature reduction.
- Classification.

Data collection and representation are mostly problem-specific. Therefore it is difficult to give general statements about this step of the process. In broad terms, one should try to find invariant features that describe the differences in classes as best as possible.

Feature selection and feature reduction attempt to reduce the dimensionality (i.e. the number of features) for the remaining steps of the task. Finally, the classification phases of the process find the actual mapping between patterns and labels (or targets). In many applications the second step is not essential or is implicitly performed in the third step.

4.2 Learning = Representation + Evaluation + Optimization

Suppose we have an application that we think machine learning might be good for. The first problem we face is the bewildering variety of learning algorithms available. Which one to use? There are literally thousands available, and hundreds more are published each year. The key to not getting lost in this huge space is to realize that it consists of combinations of just three components. The components are:

4.2.1 Representation

A classifier must be represented in some formal language that the computer can handle. Conversely, choosing a representation for a learner is tantamount to choosing the set of classifiers that it can possibly learn. This set is called the hypothesis space of the learner. If a classifier is not in the hypothesis space, it cannot be learned.

4.2.2 Evaluation

An evaluation function (also called objective function or scoring function) is needed to distinguish good classifiers from bad ones. The evaluation function used internally by the algorithm may differ from the external one that we want the classifier to optimize.

4.2.3 Optimization

Finally, we need a method to search among the classifiers in the language for the highest-scoring one. The choice of optimization technique is key to the efficiency of the learner, and also helps determine the classifier produced if the evaluation function has more than one optimum. It is common for new learners to start out using off-the-shelf optimizers, which are later replaced by custom-designed ones.

4.3 Applications Of Machine Learning

One measure of progress in Machine Learning is its significant real-world applications, such as those listed below. Although we now take many of these applications for granted, it is worth noting that as late as 1985 there were almost no commercial applications of machine learning.

4.3.1 Speech recognition

Currently available commercial systems for speech recognition all use machine learning in one fashion or another to train the system to recognize speech. The reason is simple: the speech recognition accuracy is greater if one trains the system, than if one attempts to program it by hand. In fact, many commercial speech recognition systems involve two distinct learning phases: one before the software is shipped (training the general system in a speaker-independent fashion), and a second phase after the user purchases the software (to achieve greater accuracy by training in a speaker-dependent fashion).

4.3.2 Computer vision

Many current vision systems, from face recognition systems, to systems that automatically classify microscope images of cells, are developed using machine learning, again because the resulting systems are more accurate than hand-crafted programs. One massive-scale application of computer vision trained using machine learning is its use by the US Post Office to automatically sort letters containing handwritten addresses. Over 85% of handwritten mail in the US is sorted automatically, using handwriting analysis software trained to very high accuracy using machine learning over a very large data set.

4.3.3 Bio-surveillance

A variety of government efforts to detect and track disease outbreaks now use machine learning. For example, the RODS project involves real-time collection of admissions reports to emergency rooms across western Pennsylvania, and the use of machine learning software to learn the profile of typical admissions so that it can detect anomalous patterns of symptoms and their geographical distribution. Current work involves adding in a rich set of additional data, such as retail purchases of over-the-counter medicines to increase the information flow into the system, further increasing the need for automated learning methods given this even more complex data set.

4.3.4 Robot control

Machine learning methods have been successfully used in a number of robot systems. For example, several researchers have demonstrated the use of machine learning to acquire control strategies for stable helicopter flight and helicopter aerobatics. The recent Darpa-sponsored competition involving a robot driving autonomously for over 100 miles in the desert was won by a robot that used machine learning to refine its ability to detect distant objects.

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